Saskatchewan survey of herbicide-resistant weeds in 2019 and 2020

Canada

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Introduction and Objectives

Canada is home to the third-largest number of unique herbicide-resistant (HR) weed biotypes (weed species by herbicide site of action combinations), surpassed only by the United States and Australia[1]. HR weeds occupy over half of the fields under annual crop production in the Canadian Prairies, and the number of unique HR weeds and area which they infest is growing[1,2]. Systematic surveys of HR weeds in the prairie provinces have been conducted using similar methodology for over two decades[2-4], providing a comprehensive database that may be used to understand their spatial and temporal dynamics at a landscape-scale or understand how management practices are associated with HR weed occurrence[6]. The previous 2014–2017 round of prairie surveys found HR weeds in 59%, 57%, and 68% of annual-cropped fields in Alberta, Saskatchewan, and Manitoba, respectively[2]. HR weeds were estimated to cost prairie farmers $530 million annually in reduced crop yields and quality, and increased weed control expenses. In continuation of this monitoring system, **the objective of this study was to determine the status and impact of HR weeds in Saskatchewan in 2019 and 2020**.

Materials and Methods

- Randomized-stratified pre-harvest survey conducted in August of 2019 and 2020.
- Sample sites consisted of 419 randomly-selected quarter sections (65 ha) (**Fig. 1**).
- Surveyed fields were stratified based on cultivated area within each ecodistrict and seeded area of each crop (**Table 1**).
- Mature weed seeds were collected from all uncontrolled visible weed patches and the area of each patch was estimated.
- The Mixed Grassland and Cypress Upland ecoregions were sampled in 2019, while the other ecoregions were sampled in 2020.
- Diagnostics included tier 1 acetyl-CoA carboxylase (ACCase)- and acetolactate synthase (ALS)-inhibiting herbicides (**Table 2**).
- Samples were seeded in 52 × 26 × 5 cm flats filled with soilless medium and watered daily.
- The greenhouse followed a 16 hr photoperiod with 20/18°C temperature and 230 µmol m^{-2} s^{-1} supplemental light.
- Herbicides were applied at the 2–4 leaf stage using a moving-nozzle cabinet sprayer (TeeJet® 8002VS nozzle; 275 kPa; 200 L ha^{-1} solution; 2.4 km hr^{-1}).
- Plants characterized as resistant (no injury or some injury with new growth) or susceptible (dead or nearly dead) 3 weeks after treatment relative to resistant and susceptible controls.
- Maps of resistance occurrence within each municipality were developed using QGIS 3.16[7].

Table 1. Field allocation by crop and ecoregion.

Crop	Mixed Grassland[a]	Moist Mixed Grassland	Aspen Parkland	Boreal Transition	All areas	% of all areas
	no. of fields					%
Canola	16	39	45	34	134	32
Wheat	15	27	34	7	83	20
Lentil	24	13	4	0	41	10
Durum	24	11	4	1	40	9
Barley	10	6	13	9	38	9
Oat	6	5	9	11	31	7
Field pea	11	5	8	4	28	7
Flax	2	6	3	0	11	2
Intercrops	2	0	2	1	5	1
Mustard	3	1	0	0	4	1
Soybean	1	1	1	0	3	1
Chickpea	1	0	0	0	1	1
Sub-total	115	114	123	67	419	100
% of total	28	27	29	16	100	100

[a]The Mixed Grassland ecoregion included the Cypress Upland; the Boral Transition ecoregion included the Mid-Boreal Uplands.

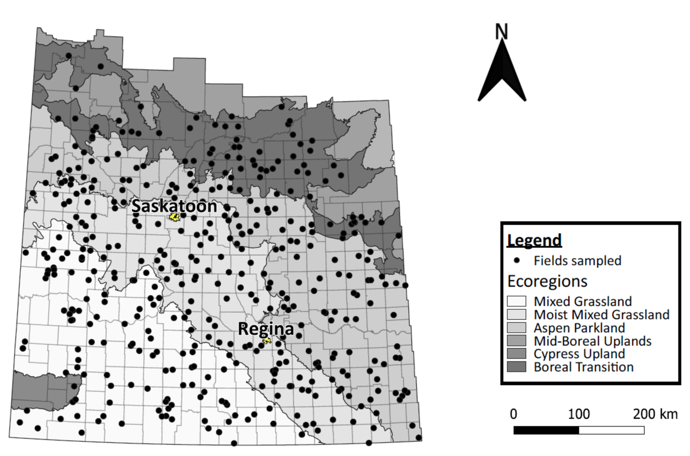


Figure 1. Locations of the 419 fields sampled.

Table 2. Herbicides used for resistance diagnostics.

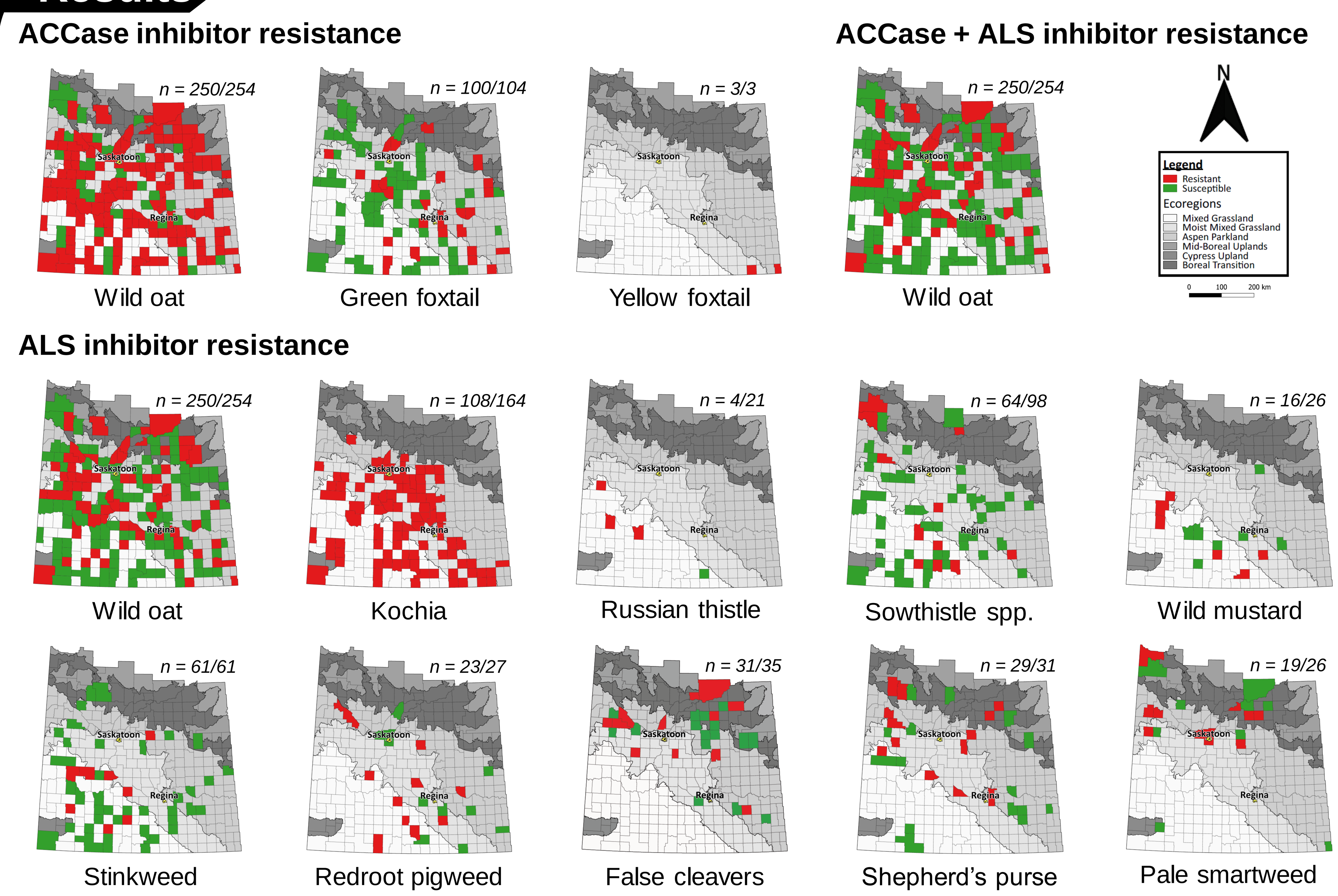
Herbicide common name	Herbicide trade name	Rate (g ai ha^{-1})
Fenoxaprop	Puma® Advance[1]	60 & 150
Sethoxydim	Poast® Ultra[2,a]	145 & 210
Imazamox	Solo® ADV[2]	35
Imazethapyr	Pursuit® 240[2,b]	75
Imazapyr	Arsenal®[2,b]	72
Thifensulfuron + Tribenuron	Refine® SG[3,c]	15(10+5)
Chlorsulfuron	Telar® XP[1,d]	89

Company name: [1]Bayer CropScience Inc.; [2]BASF Canada Inc.; [3]FMC of Canada Ltd. **Adjuvants:** [a]Merge® Adjuvant @ 0.5% v/v; [b]Agral® 90 @ 0.25% v/v; [c]Agral® 90 @ 0.2% v/v; [d]Agral® 90 @ 0.1% v/v

Results and Discussion

- 1,651 samples were collected including 44 different weed species (data not shown).
- ACCase inhibitor resistance was found in wild oat (77% of fields with the species; 47% of all fields), green foxtail (28%; 7%), and yellow foxtail (100%; 1%) (**Table 3; Fig. 2**).
- ALS inhibitor resistance was found in wild oat (30% of fields with the species; 18% of all fields), kochia (100%; 39%), Russian thistle (75%; 4%), sowthistle species (17%; 4%), wild mustard (50%; 3%), stinkweed (15%; 2%), redroot pigweed (57%; 4%), false cleavers (42%; 4%), shepherd's purse (45%; 3%), pale smartweed (47%; 3%), hemp nettle (60%; 1%), chickweed (44%; 1%), and lambsquarters (1%; <1%) (**Table 3; Fig. 2**).
- Multiple HR wild oat populations (resistant to ACCase- and ALS-inhibiting herbicides) were found in 26% of the fields with wild oat (16% of all fields) (**Table 3; Fig. 2**).
- 72% of the fields had at least one HR weed biotype present (**Table 3; Fig. 3**).
- The area with HR weeds present before crop harvest in Saskatchewan increased from 4.8 million ha (8.7 million ha field area) in 2014/2015[2] to 6.2 million ha (11.5 million ha field area) in 2019/2020 (**Table 3**).
- Based on previous grower estimates[2] combined with the area where HR weeds were present before crop harvest in Saskatchewan in 2019/2020 (**Table 3**), HR weeds cost Saskatchewan farmers about $340 million annually.

Results



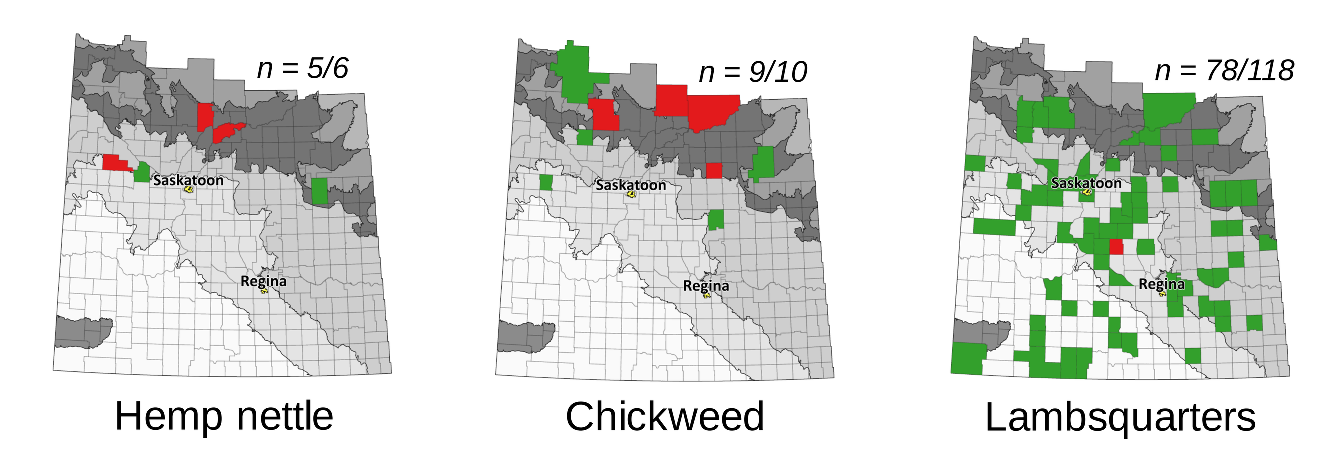


Figure 2. Maps showing the locations of populations exhibiting resistance to acetyl-CoA carboxylase (ACCase)-, acetolactate synthase (ALS)-, and ACCase + ALS-inhibiting herbicides for each weed species with resistant biotypes in a 2019/2020 survey of 419 fields in Saskatchewan. The number of samples with enough viable seeds for resistance diagnostics and the number of samples collected are shown for each species. Data are presented at the municipal scale.

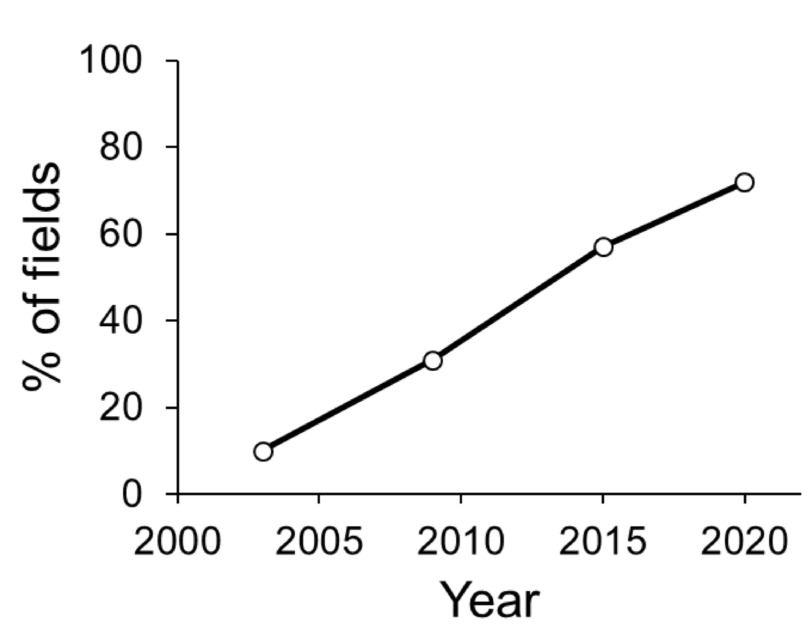


Figure 3. The percentage of sampled fields with at least one herbicide-resistant weed biotype in the current and historical[2-4] surveys of Saskatchewan.

Table 3. Frequency of confirmation of each weed biotype resistant to acetyl-CoA carboxylase (ACCase)- or acetolactate synthase (ALS)-inhibiting herbicides among fields tested and among all fields sampled, and the land area and field area occupied by each weed biotype.

Common name	Scientific name	Resistance	% of tested fields	% of all fields	Area occupied (ha)	Field area (ha)
Grass:						
Wild oat	*Avena fatua*	ACCase	77	47	3,962,167	8,347,892
Wild oat	*Avena fatua*	ALS	30	18	1,366,720	3,023,181
Wild oat	*Avena fatua*	ACCase + ALS	26	16	1,206,318	2,553,276
Green foxtail	*Setaria viridis*	ACCase	28	7	674,759	1,076,325
Yellow foxtail	*Setaria pumila*	ACCase	100	1	32,541	94,240
Broadleaf:						
Kochia	*Bassia scoparia*	ALS	100	39	3,719,244	6,890,786
Russian thistle	*Salsola tragus*	ALS	75	4	569,727	569,734
Sowthistle spp.	*Sonchus* spp.	ALS	17	4	445,105	839,937
Wild mustard	*Sinapis arvensis*	ALS	50	3	394,762	558,376
Stinkweed	*Thlaspi arvense*	ALS	15	2	245,575	364,092
Redroot pigweed	*Amaranthus retroflexus*	ALS	57	4	171,636	718,642
False cleavers	*Galium spurium*	ALS	42	4	163,771	645,306
Shepherd's purse	*Capsella bursa-pastoris*	ALS	45	3	142,146	593,429
Pale smartweed	*Persicaria lapathifolia*	ALS	47	3	132,002	450,323
Lambsquarters	*Chenopodium album*	ALS	1	<1	455	36,956
Hemp nettle	*Galeopsis tetrahit*	ALS	60	1	424	93,318
Chickweed	*Stellaria media*	ALS	44	1	323	131,997
All HR Weeds			**74**	**72**	**6,197,878**	**11,453,597**

Conclusions

Overall, **72% of the sampled fields in Saskatchewan had at least one HR weed biotype** present before crop harvest. **HR weeds occupied 6.2 million ha of cropland in 2019/2020**, representing a 29% increase from 2014/2015[2]. **HR weeds cost Saskatchewan farmers and estimated $340 million annually** in increased weed control expenses and reduced crop yields and quality. The growing impact of HR weeds warrants further investment in integrated weed management programs.

References

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[7] QGIS Development Team. 2020. www.qgis.org

Acknowledgments

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

We sincerely acknowledge the technical assistance of Taylor Kaye and Shane Hladun. We also thank Hugh Beckie for sharing his vast experience in herbicide resistance diagnostics.